An Overview of the Advanced Propulsion Research Project Office

For
Joint JPL / MSFC / UAH

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APR Overview Contents

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 - Fusion
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APR Goals and Objectives

Goals

- To enable bold new missions in space
- To enable routine economical access to space
- To enable reduced trip times throughout the solar system and beyond
- To enable routine human missions throughout the solar system, wherever and whenever.

Objectives

- Within NASA, enhance and develop capabilities
 - To perform world class advanced propulsion research
 - -To effectively manage advanced propulsion research activities across the nation
- And to utilize the expertise, experience and facilities of:
 - -Universities
 - -National Laboratories
 - -Industry





Advanced Propulsion Research Strategies

The Problem Is -

- For desired trip times around the solar system Energy requirements, expressed as Delta-V (Km/s), must increase one or two orders of magnitude
- For desired routine economical access to space the "packaged energy", expressed as a combination of specific impulse and mass fraction, must increase by an order of magnitude
- Categories of solutions:
 - More energetic fuels
 - Off board resources
- Approaches that may be able to solve the problem -
 - Beamed Energy -
 - Fusion and Exotic Nuclear
- Approaches that may provide some benefit, but short of the goals
 - Electromagnetic concepts
 - Advanced Chemical
 - Sails and tethers

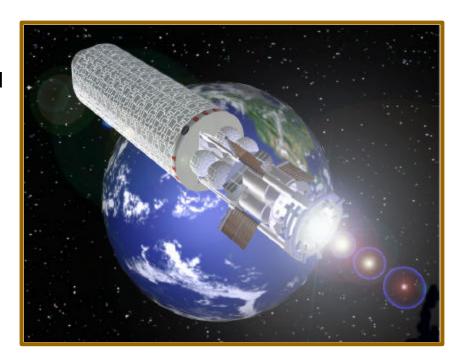






Fusion Propulsion Investment Strategy

- Fusion Propulsion High pay-off, high risk
 - DOE has actually made substantial progress
 - NASA can pursue this only with substantial DOE help
 - Fusion Propulsion Technology Working Group
 - -More than twenty well known fusion researchers from across the nation.
 - Has a draft report, examining many concepts or approaches
 - -Concludes that fusion propulsion may perhaps be demonstrable within 15-20 years



Performance

- lsp > 100,000s
- Psp ~ 10 to 60 kg
 Esp > 50 kg
- Enables fast missions anywhere in the solar system
- **Recommendation -**
 - The potential benefits demand that we start now, but with strong DOE help.

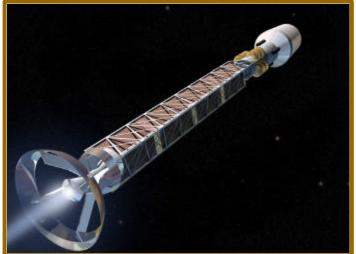


Antimatter Propulsion Investment Strategy

Antimatter

- If all the energy from antimatter annihilation can be used for propulsion, one gets an lsp > 2 Million sec.
- Current methods for producing antiprotons requires 2000 X more energy than can be obtained from it. Furthermore, the very high energy gamma rays emerging from annihilation are difficult to use.
- Alternatively, small amounts of antimatter may be effective in initiating microfission or microfusion.
- This latter concept is being studied by MSFC, JPL, Penn State. A portable antimatter trap that can hold 10^8 antiprotons for several days has now been developed and is being tested.



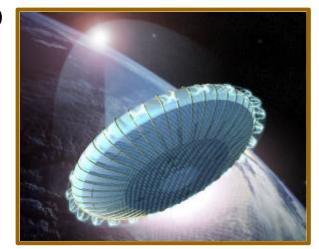




Beamed Energy Propulsion Investment Strategy

Advanced Space Transportation Program

- Beamed Energy Propulsion (ETO)
 - Obtaining orbital energies requires huge quantities of energy
 - For large payloads this will require beam sources 10,000 larger than currently published capabilities
 - Coherent phasing allows smaller units to be combined,
 - Efficiencies of beam sources is improving rapidly
 - These systems can be built, and have other applications (e.g. debris, asteroids)
 - These launch concepts may substantially reduce space access costs
 - Laser Beamed Energy
 - Can provide the Large Specific Energy needed for low cost space access
 - Pulsed Lasers can provide a niche market for microsats using megawatt class lasers
 - Microwave Beamed Energy
 - The vision mission is to propel a large lenticular helium balloon into space.
- Beamed Energy (In-Space)
 - Propellantless propulsion
 - Very high power lasers with large apertures
 - Precision pointing
 - Large, low density sails



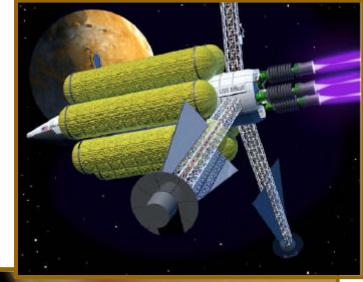




Nuclear Fission Propulsion Investment Strategy

Advanced Nuclear Thermal and Nuclear Electric

- Advanced Nuclear Thermal Rockets (NTR) typically flow hydrogen gas through the reactor core to heat the gas which provides thrust by expanding through a nozzle. This system provides high thrust with Isp > 800 s.
- Advanced Nuclear Electric Propulsion (NEP) typically uses a nuclear reactor to generate electric power (similar to a submarine) which is used to power an electric propulsion system. Low thrust with lsp >> 5000 s.
- Why should we consider Nuclear Propulsion
 - Chemical propulsion systems have been pushed to limit. Maybe another few % left.
 - Nuclear could put us on a new growth path with a factor of 1,000,000 improvement in specific energy, a factor of 10 to 100 in ISP.
 - In the event the nation decides to pursue this, to be at least a little prepared, a small amount of research now is appropriate.







Advanced Chemical Propulsion Investment Strategy

Advanced Chemical Fuels

- Recombination energy fuels
 - This high risk monopropellant may offer lsp improvement to 550-700 sec
- Advanced hydrocarbon fuels
 - These AFRL developed RP-like fuels offer lsp = 20
 s, specific q = 1.1
 - Enhanced performance of existing first stages may reduce cost/pound

Pulse Detonation Engines

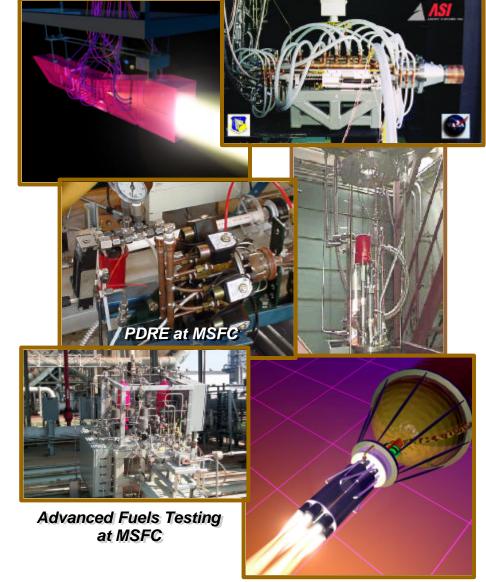
- Existing codes with various assumptions give widely different predictions
- The government needs a standardized code to enable evaluations
- A government engine is needed to benchmark codes.

Advanced Cycles and Components

- LACE, DCARE, etc. may offer some performance improvements
- Air Force and NASA are collaborating in these areas.

Recommendations

- Enhance the advanced fuels activities
- Contribute to the joint AF, Navy, NASA, industry standard PDE code dev.
- In-house PDRE to benchmark code, and publish
- Participate with the AF in deeply cooled air heat exchanger design.





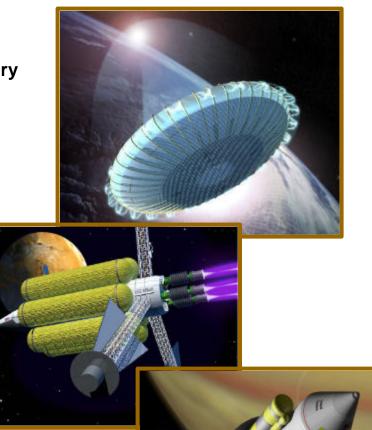
New Task Selection Methodology

NASA internal new tasks

- Proposal is evaluated by an informal research advisory group within that center
- Constrained by available budget and available supporting manpower
- Criteria consistent with project objectives

External Tasks

- Unsolicited Proposals
 - Ad Hoc Research Advisory Panel created to evaluate proposal
 - Follows normal procurement procedures
 - Constrained by available budget
 - Very few are selected
- NASA Research Announcements
 - Preferred approach
 - Need about \$1-2M to be effective, several selections
 - Insufficient research funds have been available for the past several years to release an Advanced Propulsion NRA







- Avenues exist for advanced propulsion research that may lead to enabling bold new capabilities in space travel
- Some limited research is underway
- Exciting possibilities lie ahead

